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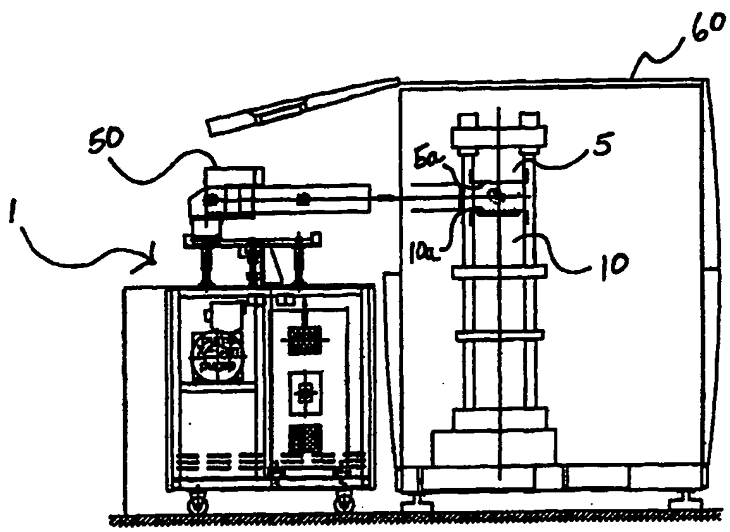

(57) Abstract

The present invention utilizes laser to remove the surface contaminants such as grease, wax, and resin residue from a mould used in semiconductor packaging tools. The contaminant removal process utilizing the laser involves shooting a beam of laser onto the surface of the mould having the contaminants. The laser is delivered as a pulse which lasts only a short duration. Multiple pulses may be required to completely remove the contaminants. Because the area of coverage for each pulse is usually much smaller than the total area of the mould surface, the laser needs to be moved around until the entire mould surface has been exposed to the laser. Because fumes are produced as the laser disintegrates the contaminants, some type of vacuum should be used to remove the residual gas and other debris.

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A SYSTEM FOR REMOVING SURFACE CONTAMINANTS ON MOULDS USED IN SEMICONDUCTOR PACKAGING TOOLS

FIELD OF THE INVENTION

The present invention relates generally to the field of semiconductor packaging, and in particular, to a laser cleaning method and system for removing surface contaminants on moulds used in semiconductor packaging tools.

BACKGROUND OF THE INVENTION

The process for packaging semiconductor devices is well known to those skilled in the art. Generally speaking, the process typically involves placing a chip-carrying substrate between two mould halves, closing the mould halves, and injecting a type of resin material under intense heat and pressure to liquefy and cure the resin material. This is a high-volume process in the sense that a large number devices are typically processed in a relatively short time.

The encapsulation process often leaves surface contaminants on the surface of the moulds which can get quite heavy after several hours of continuous running of the packaging tool. These contaminants can be grease, wax, and residual resin. Because the encapsulation process occurs under intense heat and pressure, the contaminants adhere firmly to

th surface such that the removal of the contaminants become an extrem ly difficult task.

Consequently, the removal of these surface contaminants is an involved process. Currently, the cleaning of the moulds is accomplished by injecting a substance called malamine into the empty moulds, exposing it to intense heat and pressure to liquefy the substance, and then letting it solidify. During this process, the contaminants react with the malamine compound and bond to its surface of the solidified malamine compound. Once solidified, the malamine compound is thrown out.

Although this is an established method of mould cleaning which is used extensively in the industry, it has a number of shortcomings. For one, it is time consuming; the whole process can take more than two hours. In an industry where high-volume production is of paramount importance, this expenditure of time can be quite costly. Moreover, the cleaning process is not complete in that even after the process, some residual contaminants remain. These residues can be detrimental to the encapsulation process as they may lead to defective packages. Furthermore, the cleaning material, malamine, releases toxic fumes which are harmful to human beings. Hence a careful handling of the malamine material is necessary to minimize danger.

For these reasons, there is a great need in the industry to have an effective cleaning process. Ideally, such a process should be fast, complete, and relatively safe. However, as of this date, the industry has not had success in coming up with such a cleaning system in the semi-conductor packaging industry.

OBJECT OF THE INVENTION

Therefore, it is an object of the present invention to provide a process and system for removing surface contaminants on moulds used in semiconductor packaging tools where the cleaning process is fast, complete, and relatively safe.

SUMMARY OF THE INVENTION

The present invention utilizes laser to remove the surface contaminants such as grease, wax, and resin residue from a mould used in semiconductor packaging tools. Generally, the contaminant removal process utilizing the laser involves shooting a beam of laser onto the surface of the mould having the contaminants. The laser is delivered as a pulse which last only a short duration, e.g., 23 nanoseconds (ns). Multiple pulses may be required to completely remove the contaminants. Because the area of coverage for each pulse is usually much smaller than the total area of the mould surface, the laser beam needs to be moved around until the entire mould surface has been exposed to the laser. Because fumes are produced as the laser disintegrates the contaminants, some type of vacuum should be used to remove the residual gas and other debris.

To successfully use the laser process, a number of factors should be considered in producing an optimal result. For one, the process should be relatively fast--that is, the laser should not take an in rdinat time to rem ve th surfac contaminants. The removal process should also be complete--

that is the laser should r mov all or substantially all of the surfac contaminants. In addition, th removal process should be non-invasive--that is, it should not damage the mould surface in any substantial way.

To produce the optimal result, a number of laser parameters must be controlled. These parameters are, for example: type of laser, power output, wavelength of the laser, type of laser delivery (pulse or continuous), etc. For the present system, while there exists many laser types, it is preferable to utilize a laser which produces a pulse laser beam having a homogeneous energy profile, and which is non-coherent. These conditions allow for higher peak power, better control of the laser beam and thus a better contaminant removal process. It has been shown that KrF excimer laser has such properties, and thus, is a preferred laser type, though other laser types may carry these properties as well. Also, it is preferred that the laser pulse carry a pulse width of 23 ns (nanoseconds).

To successfully remove the contaminants, the laser beam must have sufficient power at a particular wavelength. For laser applications, power is defined in terms of fluence which is defined as energy divided by area where the units are mJ/cm^2. The wavelength is typically measured in nano-meters or "nm" for short. Although a range of wavelengths is certainly possible, the preferred wavelength is 248 nm. Similarly, while a range of power output is possible, the preferred power output is 300 mJ/cm^2.

It is important not to use a power output which may damage the mould surface beneath the contaminants. The amount of power required to cause damage depends partly on the wavelength of the laser and the type and nature of th material being hit by the laser.

In the preferred setting, i. ., KrF excimer laser with a wav l ngth of 248 nm, a pulse width of 23 ns, a pulse area of coverage of 1 cm^2, and a fluence level of 300 mJ/cm^2, it takes at least two pulses at the same location to ensure complete removal of the contaminant layer within the area of coverage. The contaminant layer is typically about 1 to 2 μm in thickness. The 1 to 2 μm contaminant depth was formed from continuous running of the encapsulating tool for a period of about 24 hours. Where the tool is left to run for a longer period, the thickness of the contaminant layer would, of course, increase. To account for the different thickness of the contaminant layer, either the pulse width or the number of pulses per area or a combination of both needs to be modified, though a change in some of the other parameters may also work.

Taking the 1 to 2 μm thickness as an example, the entire mould surface (which has a surface area of about 468 cm^2), can be cleaned in about 2 to 3 minutes using the process parameters described above. However, to decrease the total time for the cleaning, the pulse area of coverage can be increased. The pulse area of coverage is basically determined by the size of the laser beam; the larger the size, the larger the area covered by each pulse.

Because the mould surface has various cavities for receiving a semiconductor device and for delivering the resin, the mould surface is not completely flat. At times, particularly if the size of the laser beam is quite large, the laser pulse may simultaneously expose two or more surfaces of different depths. Although the laser energy level is generally uniform over a distance, the focus length may facilitate a difference in the laser energy levels for the diff rent depth. This difference can be significant where the

focus length is very small. To avoid this probl m, it is pr ferable hav a v ry long focus length and to us a collimated b am.

The cavities on the moulds create one additional problem for the laser cleaning process. It is typical for the cavities to have side walls which are perpendicular to the main surface of the mould. If the laser were to be shot perpendicular to the surface of the mould, the side walls would not receive enough energy from the laser beam, as the beam would essentially be parallel to the side walls. To avoid this problem, it is preferred that the laser beam be shot at an angle to the mould surface. This way, all surfaces can receive sufficient energy from the laser.

In the preferred embodiment of the present invention, the laser cleaning process is implemented as a standalone cleaning system which can be steered next to any semiconductor encapsulating tool using a mould. In the system, the laser beam is directed via several mirrors to reach an intended target. In the system, a mirror is positioned in between the mould halves of an encapsulating machine. The mirror is attached to a robotic arm which can precisely rotate the mirror to any angle, and which can also precisely displace the mirror in any position in the plane parallel to the surfaces of the moulds. The robotic arm is attached to an X-Y table which facilitates the positioning of the robotic arm. The mirror receives the laser beam which is directed via a series of other mirrrors.

To operate the cleaning system, the standalone unit, is steered close to the moulding machine. The robotic arm is extended in between the two mould halves, and aligns the mirror to a reference point on the surface of th mould. Once aligned, the laser generator mits two puls s of laser b am which are directed to an area on the surface of the mould via

a s ries of mirrors. As th contaminant layer is disintegrated, a suction syst m sucks out th fumes and other debris. Onc the contaminant for th area is removed, the X-Y table is moved to a next location and the removal process is initiated again. The process repeats itself until the entire surface of the mould is completed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of the preferred embodiment of the present system standing adjacent to a mould assembly typically used in semiconductor packaging machines.

FIG. 2 is a schematic diagram of the beam delivery assembly for the preferred embodiment of the present system.

FIG. 3 is a schematic diagram of the X-Y table for the preferred embodiment of the present system.

FIG. 4 is an Auger Electron Spectroscopy (AES) spectrum graph illustrating the depth profile of a contaminant layer typically found on moulds used in semiconductor packaging machines before undergoing the laser cleaning process of the present invention.

FIG. 5 is an Auger Electron Spectroscopy (AES) spectrum graph illustrating the depth profile of a contaminant layer typically found on moulds used in semiconductor packaging machines after undergoing the laser cleaning process of the present invention.

FIG. 6 is an Auger Electron Spectroscopy (AES) spectrum graph illustrating the depth profile of a contaminant layer typically found on

moulds used in semiconductor packaging machines after undergoing th laser cl aning process of the present invention for on continuous hour.

DETAILED DESCRIPTION OF THE INVENTION

The present invention utilizes laser to remove the surface contaminants such as grease, wax, and resin residue from a mould used in semiconductor packaging tools. Generally, the contaminant removal process utilizing the laser involves shooting a beam of laser onto the surface of the mould having the contaminants. The laser is delivered as a pulse which last only a short duration, e.g., 23 nanoseconds (ns). Multiple pulses may be required to completely remove the contaminants. Because the area of coverage for each pulse is usually much smaller than the total area of the mould surface, the laser beam needs to be moved around until the entire mould surface has been exposed to the laser. Because fumes are produced as the laser disintegrates the contaminants, some type of vacuum should be used to remove the residual gas and other debris.

To successfully use the laser process, a number of factors should be considered in producing an optimal result. For one, the process should be relatively fast--that is, the laser should not take an inordinate time to remove the surface contaminants. Although the speed of removal can vary depending on the parameters which are chosen for the laser, preferably, the parameters should be selected such that the duration required to remove all of the contaminants from a single mould half (either bottom or top half) should be no more than 5 minutes.

The removal process should also be complete--that is the laser should remove all or substantially all of the surface contaminants. Th level of completeness required, of course, depends on the process specification. In addition, the removal process should be non-invasive--that is, it should not damage the mould surface in any substantial way. For instance, the mould surface typically has a chrome coating over a steel substrate, and it is important that the laser beam does not cause the peeling of this coating or damage the underlying substrate. And lastly, the process should be relatively safe to the people operating the laser cleaning system.

To produce the optimal result, a number of laser parameters must be controlled. These parameters are, for example: type of laser, power output, wavelength of the laser, type of laser delivery (pulse or continuous), etc. For the present system, while there exists many laser types, it is preferable to utilize a laser which produces a pulse laser beam having a homogeneous energy profile, and which is non-coherent. These conditions allow for higher peak power, better control of the laser beam and thus a better contaminant removal process. It has been shown that KrF excimer laser has such properties, and thus, is a preferred laser type, though other laser types may carry these properties as well. Also, it is preferred that the laser pulse carry a pulse width of 23 ns (nanoseconds).

Experiments have shown that at least one type of laser may not be optimal for the removal of contaminants on a mould surface. For instance, an experiment using a YAG laser, a beam having a wavelength of 532 nm and another b am having a wavelength of 1064 nm, both having a puls width of 7 nano-second, did not produce optimal results because the las r

beams, while did remove the surface contaminants, tended to easily damage the mould surface, a highly undesirable result.

To successfully remove the contaminants, the laser beam must have sufficient power at a particular wavelength. For laser applications, power is defined in terms of fluence which is defined as energy divided by area where the units are mJ/cm^2. The wavelength is typically measured in nano-meters or "nm" for short. Although a range of wavelengths is certainly possible, the preferred wavelength is 248 nm. Similarly, while a range of power output is possible, the preferred power output is 300 mJ/cm^2.

Choosing the proper wavelength and power output is important, and several factors must be taken into consideration. For the wavelength, it should short enough that there is sufficient energy absorption by the contaminant material. For the present application, it has been found that 248 nm was sufficient. For the power output, the power should exceed the minimum threshold for removing the contaminants. This threshold depends mainly on the chemical composition of the contaminants. For the types of contaminants typically found in mould surfaces of semiconductor packaging tools, e.g., grease, wax, resin residues, which are usually carbon-based, the threshold was generally found to be around 150 mJ/cm^2 at the wavelength of 248 nm.

The minimum power output, however, while sufficient for removing the contaminants, may not be optimal because the rate of removal may be slow or the removal process may not be complete, that is, some residue may be left over and hence many pulses may be required for a complete removal. Hence, it may be desirable to operat the laser at a higher than the minimum threshold to spe d up the process. In addition, the removal

performanc can b increased by using a shorter wavelength for the las r, and thus, incr asing the amount of laser absorption.

Although higher power may increase the removal rate and therefore generally desirable, it is equally important not to use a power output which may damage the mould surface beneath the contaminants. Again, the amount of power required to cause damage depends partly on the wavelength of the laser and the type and nature of the material being hit by the laser. In the case of moulds being used in the semiconductor packaging industry, it is typically for the moulds to have a 2 to 3 μm chrome coating over a steel substrate. A common material for the substrate is AST powder high speed steel. For this situation, it is very important that the laser does not cause any degradation in the chromium coating or in the steel substrate itself. It is particularly important that the cleaning process does not cause the chromium coating to peel.

Two important concepts in analyzing power output as related the possiblity of damage to the underlying material are thermal diffusion length μ and temperature rise ΔT on the surface of the mould, both of which are well-known concepts to those skilled in the art. It was determined empirically that μ in the present case was 1.42 μm which is less than the thickness of the chromium coating. Generally, it is desirable to have a low μ, and particularly in this case, it is preferable that μ does not exceed the thickness of the chromium coating.

The difference in the thermal expansion between the chromium coating and the underlying substrate steel generally becomes significant after an average temperature ris of over 400 degree Celsius, and hence, it is desirable to avoid a power output of th las r which will cause a

temperature rise exceeding this lev l. A laser fluence of 200 mJ/cm^2 with pulse width of 23 ns resulted in an av rage temperature rise of 175 degrees Celsius, and a laser fluence of 300 mJ/cm^2 at the same pulse width resulted in an average temperature rise of 227 degrees Celsius, both below the undesirable level of 400 degree rise. Although the precise output level which would cause a temperature rise of 400 degrees Celsius is not known with certainty, it is believed that damage to the mould surface may occur at the fluence level of about 1500 mJ/cm^2.

In the preferred setting, i.e., KrF excimer laser with a wavelength of 248 nm, a pulse width of 23 ns, a pulse area of coverage of 1 cm^2, and a fluence level of 300 mJ/cm^2, it takes at least two pulses at the same location to ensure complete removal of the contaminant layer within the area of coverage. The contaminant layer is typically about 1 to 2 μm in thickness. The 1 to 2 μm contaminant depth was formed from continuous running of the encapsulating tool for a period of about 24 hours. Where the tool is left to run for a longer period, the thickness of the contaminant layer would, of course, increase. To account for the different thickness of the contaminant layer, either the pulse width or the number of pulses per area or a combination of both needs to be modified, though a change in some of the other parameters may also work. For instance, if the contaminant layer is twice as thick, i.e. 4 μm, the pulse width may need to be doubled, or possibly, four, instead of two, pulses may be needed. However, because the process is not entirely linear, it may not always be true that the doubling of the thickness of the contaminant layer necessary requires doubling of the process parameter. Hence, some xperiment may be needed to find an optimal pulse width and/or number of pulses which is required for effectiv

removal of the contaminant layer in a given area of cov rage.

Taking th 1 to 2 μm thickn ss as an example, the ntire mould surface (which has a surface area of about 468 cm^2), can be cleaned in about 2 to 3 minutes using the process parameters described above. However, to decrease the total time for the cleaning, the pulse area of coverage can be increased. The pulse area of coverage is basically determined by the size of the laser beam; the larger the size, the larger the area covered by each pulse. However, because fluence is defined as laser energy divided by surface area, increasing the area of coverage per pulse requires the increase in the laser energy per pulse if the same fluence is to be maintained. Depending on how large the area of coverage is, a more powerful laser generator may be required. Of course, another way to decrease the cleaning time is to simply have multiple laser beams shooting at different areas, though this may require multiple laser generators and/or a more powerful laser which can be split into multiple beams.

Because the mould surface has various cavities for receiving a semiconductor device and for delivering the resin, the mould surface is not completely flat. At times, particularly if the size of the laser beam is quite large, the laser pulse may simultaneously expose two or more surfaces of different depths. Although the laser energy level is generally uniform over a distance, the focus length may facilitate a difference in the laser energy levels for the different depth. This difference can be significant where the focus length is very small. To avoid this problem, it is preferable have a very long focus length and to use a collimated beam. As an illustration, a typical mould can have a cavity which is about 5 mm in depth. If a focus length of 150 mm is chosen, th difference in th energy deliv red to the

different d pths would be only around 6.8 % which would be an acc ptable difference. Of course, this difference can be further reduced by having a even larger focus length.

The cavities on the moulds create one additional problem for the laser cleaning process. It is typical for the cavities to have side walls which are perpendicular to the main surface of the mould. If the laser were to be shot perpendicular to the surface of the mould, the side walls would not receive enough energy from the laser beam, as the beam would essentially be parallel to the side walls. To avoid this problem, it is preferred that the laser beam be shot at an angle to the mould surface. This way, all surfaces can receive sufficient energy from the laser. Although the angling of the laser will slightly increase the area of coverage for each laser pulse, this will not be significant, or it can be rectified by increasing the energy level of the pulse.

FIGS. 4 through 6 demonstrate the effectiveness of this above described cleaning process. FIGS. 4 through 6 illustrate the Auger Electron Spectroscopy (AES) graphs which can be used to analyze the composition of materials at different depths. AES technology is generally well-known to those skilled in the art.

FIG. 4 is a graph illustrating the composition of an actual contaminant layer found on a mould surface having a chromium coating before the mould underwent the laser cleaning process. Each of the curves represents a particular depth below the surface of the top layer. Hence, a depth of 0 in this case would be the very top of the contaminant layer. The various peaks indicate the presence of a particular material; generally, the higher the peak, the greater th presence. The peaks marked "C" indicate

the presenc of carbon; the p aks marked "Cr" indicate the presence of chromium; the peaks marked "O" indicate th presence of oxyg n in the form of oxide. Much of the contaminants found in semiconductor packaging tools carry carbon, and hence, high presence of carbon indicates high levels of contaminants. The presence of oxide is generally indicative of damage which may have occured on the surface of the chromium coating, as the laser can cause oxidation on this surface. Some oxide can also come from the contamination itself. The presence of chromium, on the other hand, is desirable since this is the coating material for the mould surface. As can be seen from the graph in FIG. 4, there is a high level of carbon almost up to a depth of 104 nm.

Compare graph in FIG. 4 to one in FIG. 5. FIG. 5 illustrates the composition of the contaminant layer after undergoing the laser cleaning process. Note that a slight level of carbon can be found only at the very top of the layer, and the level drop signficantly even after only a few nanometers in depth. On the other hand, there is a high level of chromium through the entire layer. Some level of oxide is found only near the top layer, which indicates that there is no damage to the chroming surface but that oxide has been absorbed during the transportation of the mould from the cleaning stage to the measuring stage.

In the preferred embodiment of the present invention, the laser cleaning process is implemented as a standalone cleaning system 1 which can be steered next to any semiconductor encapsulating tool 60 using a mould, as illustrated in FIG. 1. Although one of ordinary skilled in the art can certainly appreciate the multitude of ways this process can b implem nted, a preferred impl m ntation is illustrated in FIGS. 1, 2, and 3.

As illustrated in FIG. 2, the laser beam 2 is direct d via s v ral mirrors to reach an int nd d target. The laser generator 20 generat s a pulse laser beam 2 which is directed to a beamsplitter which splits a portion of the beam onto a mirror m1 which directs the beam 2 onto mirror m2. The othe portion of beam is used to monitor the power level of the laser. The mirror m2 redirects the beam 2 onto m3 which redirects the beam 2 towards lens 1, 30, and lens 2, 35. The lens 1 and 2 collimate the beam 2 which thereafter hits mirror m4. Mirror m4 redirects the beam 2 onto the mould surface. Of course, the number of mirrors needed is depended on the structure of the system and the need to direct the beam in a particular path, and is not integral to the laser cleaning process.

Now referring to FIG. 1 and FIG. 3, the mirror m4 is positioned in between the mould halves 5 and 10. The mirror m4 is attached to a robotic arm (shown in FIG. 3, but not shown in FIG. 1) which can precisely rotate the mirror m4 to any angle, and which can also precisely displace the mirror in any position in the plane parallel to the surfaces 5a and 10a of moulds 5 and 10. The robotic arm is attached to an X-Y table 50 which facilitates the positioning of the robotic arm.

FIG. 3 illustrates a schematic diagram of the X-Y table 50 of FIG. 1. As can be seen, the mirror m4 is attached to the robotic arm 52 which is attached to the X-Y table 50. The mirror m4 receives the laser beam 2 which is directed via mirrors m3, m2, and m1 as shown in FIG. 2.

Now referring to FIGS. 1, 2 and 3, to operate the cleaning system, the standalone unit 1, is steered close to the moulding machine 60. The robotic arm 52 is extended in between the two mould halves 5 and 10, and aligns the mirror m4 to a ref rence point on the surface of the mould 10.

Once aligned, the laser generator 20 emits two pulses of laser beam 2 which are directed to an ar a on the surface of th mould 10 via a seri s of mirrors m1, m2, m3 and m4. The angle at which the laser is directed onto the surface of the mould and the energy level of the laser depend somewhat on the type of mould being used, as explained above. As the contaminant layer is disintegrated, a suction system (not shown) sucks out the fumes and other debris. Once the contaminant for the area is removed, the X-Y table is moved to a next location and the removal process is initiated again. The process repeats itself until the entire surface of the mould 10 is completed. Thereafter, the mirror m4 is rotated such that the laser beam is directed to the top mould 5, and the cleaning process is repeated per the same process applied for the bottom mould 10.

Although here, the preferred embodiment of the laser cleaning system was a standalone system, it should be appreciated that it can easily be integrated into the encapsulating tool itself. And although here only one laser system was shown, it is entirely possible to have multiple units cleaning several moulds at the same time. Moreover, a single laser beam may be split into multiple beams so that the upper and lower moulds can be cleaned simultaneously.

Therefore, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are, therefore, to be mbrac d th rein.

CLAIMS

We Claim:

1. A system for removing surface contaminants from a mould used in semiconductor packaging tool comprising:

a laser generator for generating a beam of laser; and

a means for directing said beam into an area of coverage on the surface of the surface of the mould,

whereby said beam of laser removes substantially all of the contaminants in said area of coverage.

2. The system as recited in claim 1 further comprising a beamsplitter and a means for monitoring power of beam of laser.

3. The system as recited in claim 1 further comprising a means for collimating said beam.

4. The system as recited in claim 1 wherein said contaminants comprise grease, wax, and resin residue.

5. The system as recited in claim 1 said means comprise at least one mirror.

6. The system as recited in claim 5 further comprising a means for directing the beam anywhere on the surface of the mould.

7. The system as recited in claim 6 wherein said means for directing the beam anywhere on the surface of the mould is an X-Y table.

8. The system as recited in claim 1 wherein said system is a fre standing syst m.

9. The system as recited in claim 1 further comprising a means for r moving fumes and debris.

10. The system as recited in claim 1 wherein said laser is a KrF excimer pulse laser.

11. The system as recited in claim 10 wherein said beam of laser is emitted between a power range of 149 and 301 mJ/cm^2.

12. The system as recited in claim 11 wherein said beam of laser is emitted at a wavelength of 248 nanometers.

13. The system as recited in claim 12 wherein said beam of laser has a pulse width of 23 nanoseconds.

14. The system as recited in claim 13 wherein said beam of laser is emitted at an angle to the surface of the mould.

15. The system as recited in claim 14 wherein said beam of beam is collimated.

16. The system as recited in claim 15 wherein said area of coverage is approximately 1 cm^2.

17. The system as recited in claim 16 wherein a total duration for removing all of the contaminants on the surface of the mould is less than 5 minutes.

18. The system as recited in claim 3 wherein said laser is a KrF excimer pulse laser.

19. The system as recited in claim 18 wherein said beam of laser is emitted between a power range of 149 and 301 mJ/cm^2.

20. The system as recited in claim 19 wherein said beam of laser is emitt d at a wav l ngth of 248 nanometers.

21. The system as recited in claim 20 wherein said beam of laser has a pulse width of 23 nanoseconds.

22. The system as recited in claim 21 wherein said beam of laser is emitted at an angle to the surface of the mould.

23. The system as recited in claim 22 wherein said area of coverage is approximately 1 cm^2.

24. The system as recited in claim 23 wherein a total duration for removing all of the contaminants on the surface of the mould is less than 5 minutes.

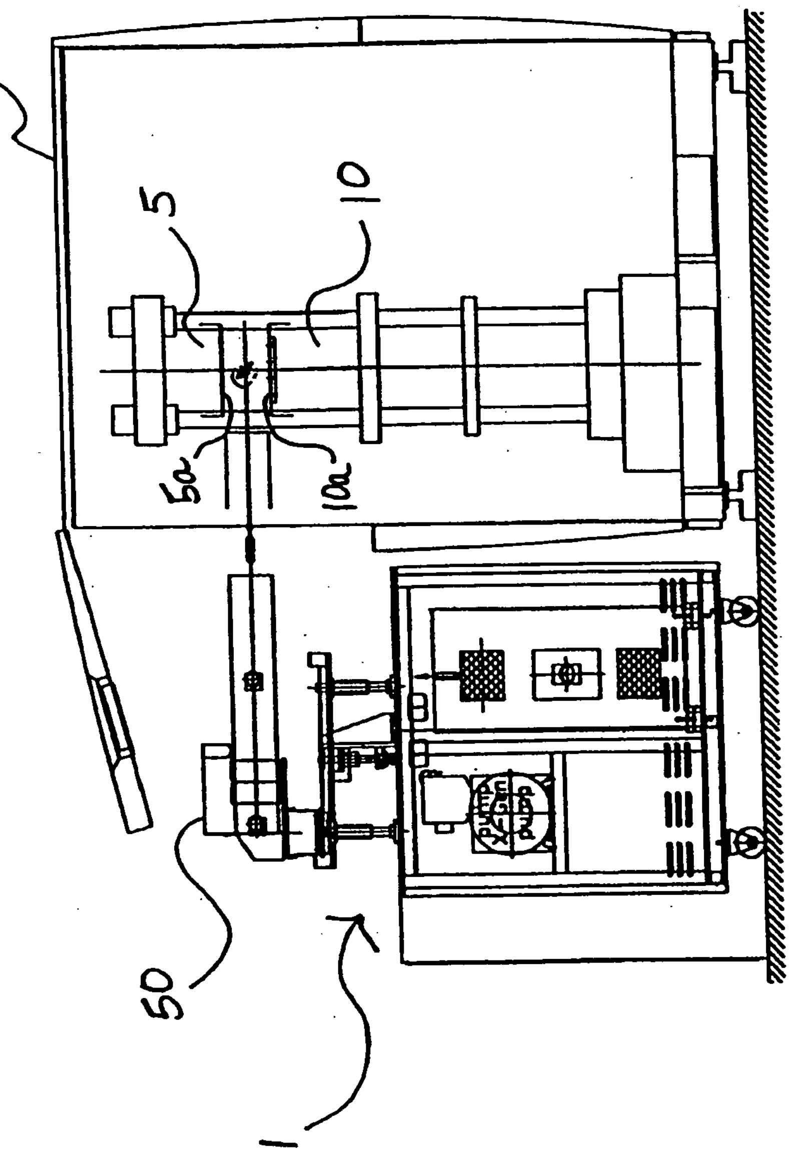

FIG. 1

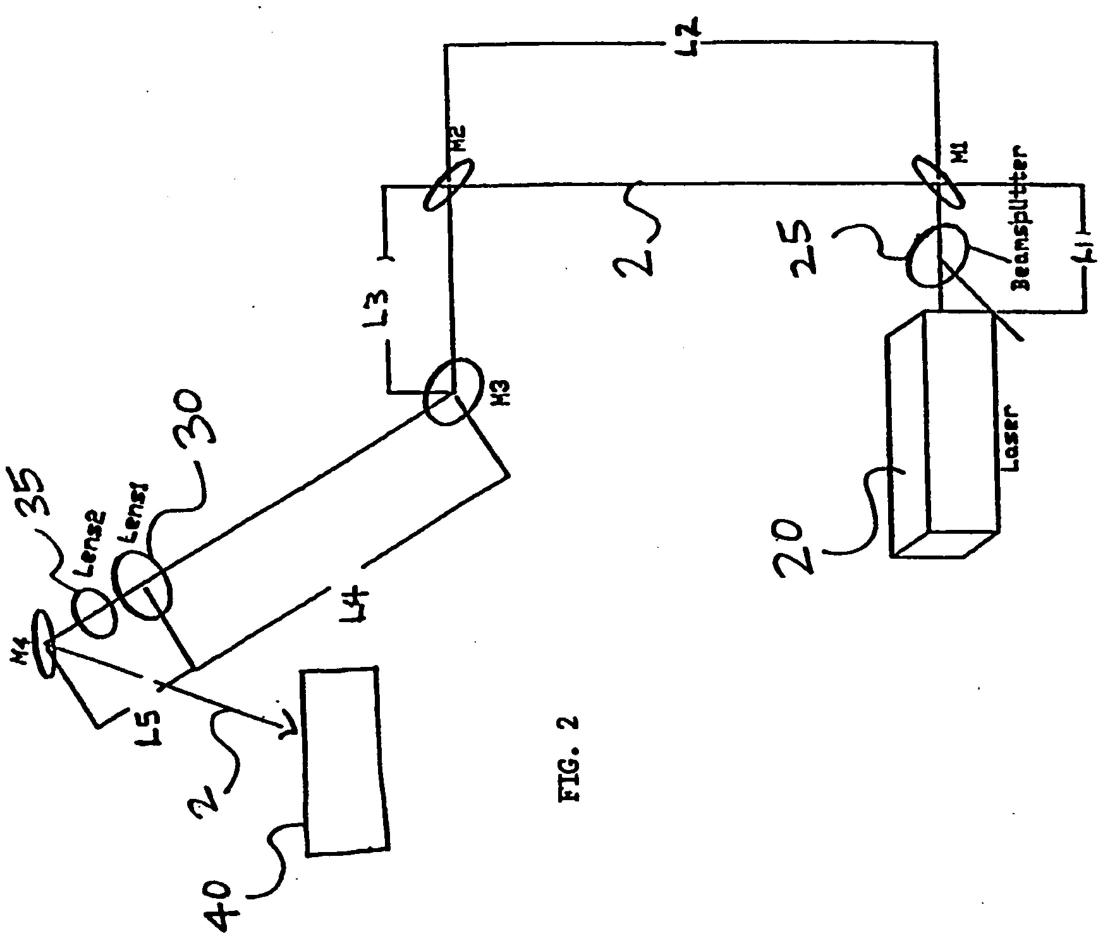
L2
M2
M1
Beamsplitter
L1
25
2
L3
M3
Laser
20
30
35
Lens2
Lens1
L4
M4
L5
2
40

FIG. 2

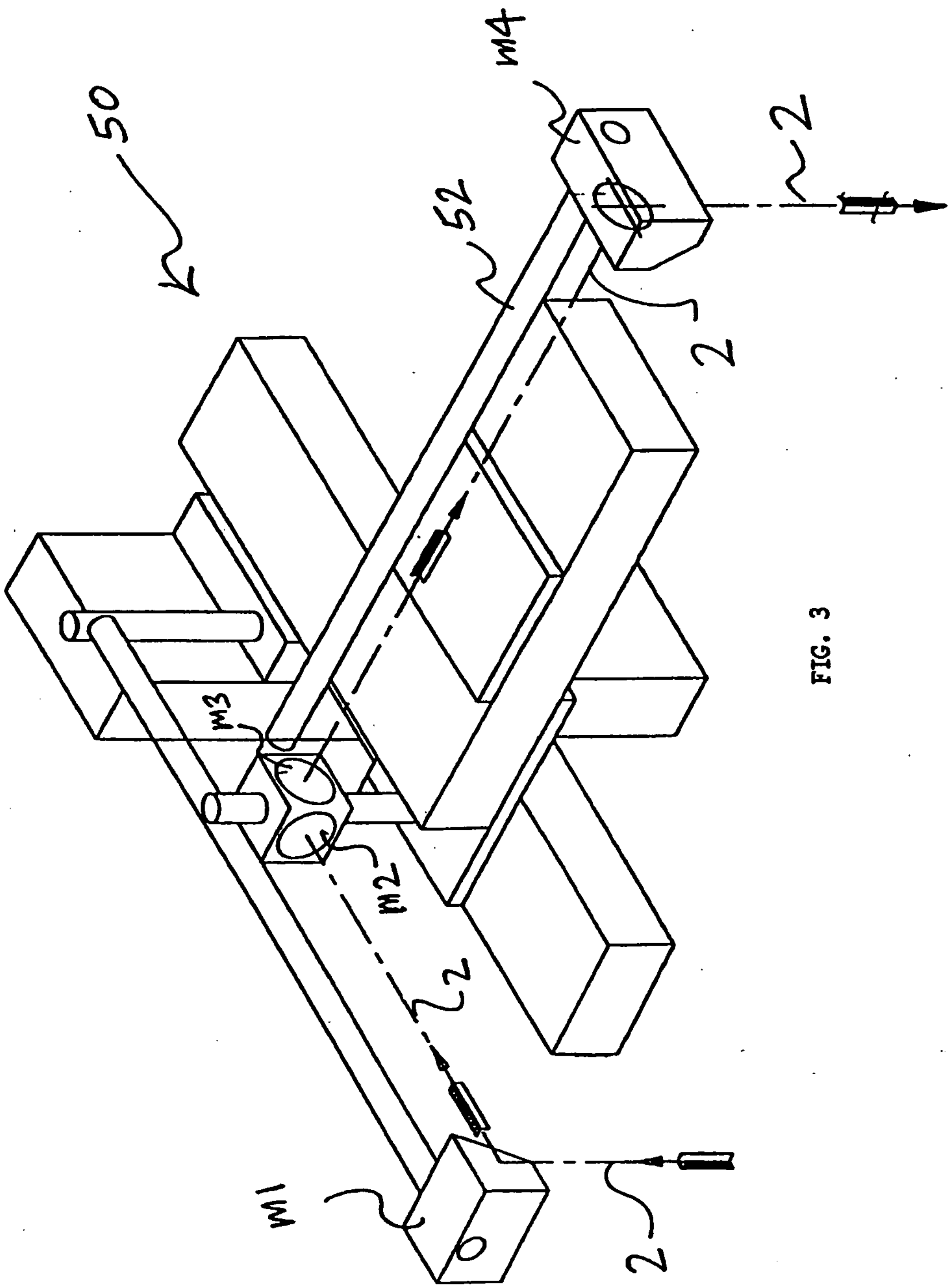

FIG. 3

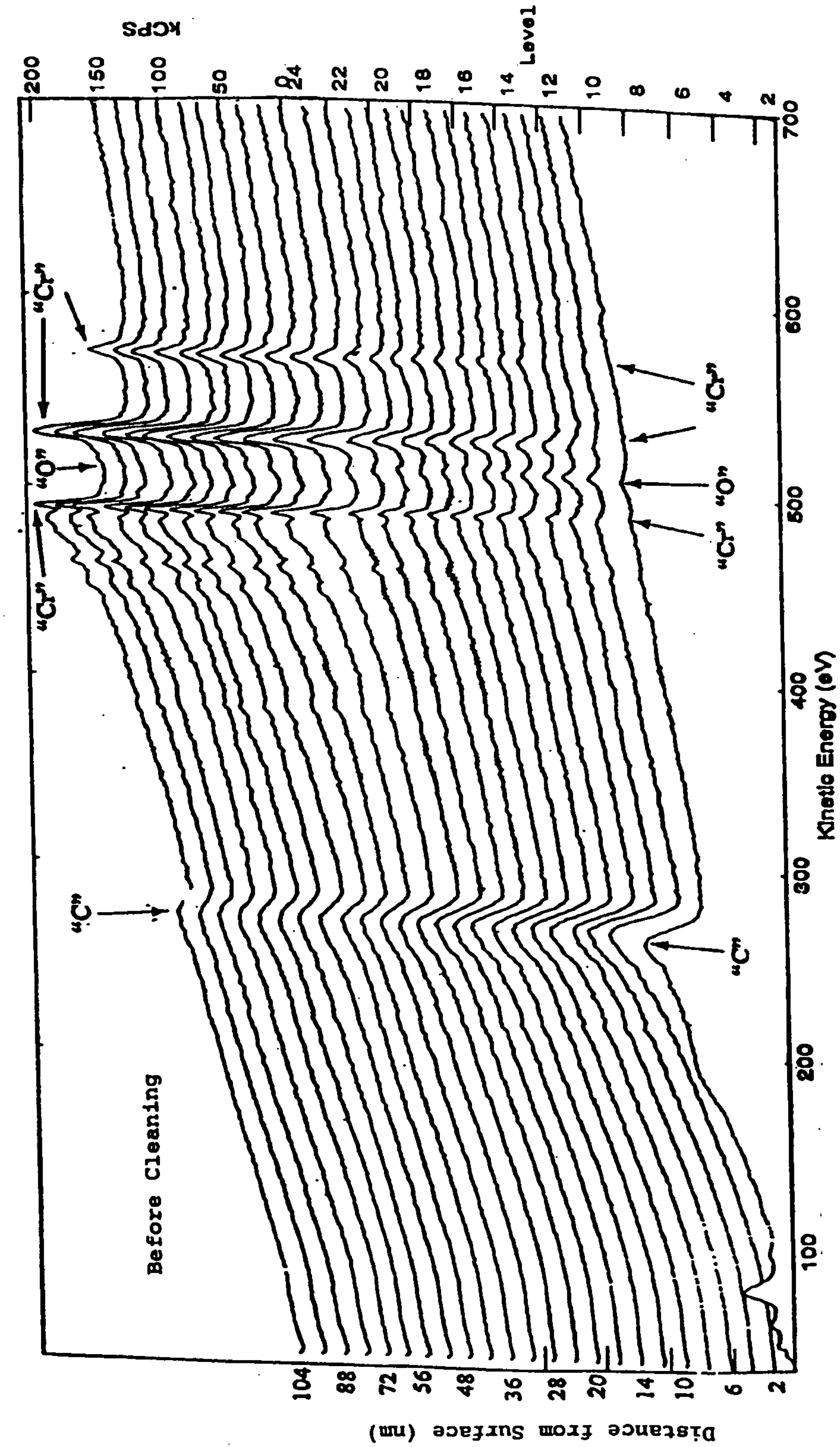
KCPS
Level
Before Cleaning
"Cr"
"O"
"C"
Kinetic Energy (eV)
Distance from Surface (nm)

FIG. 4

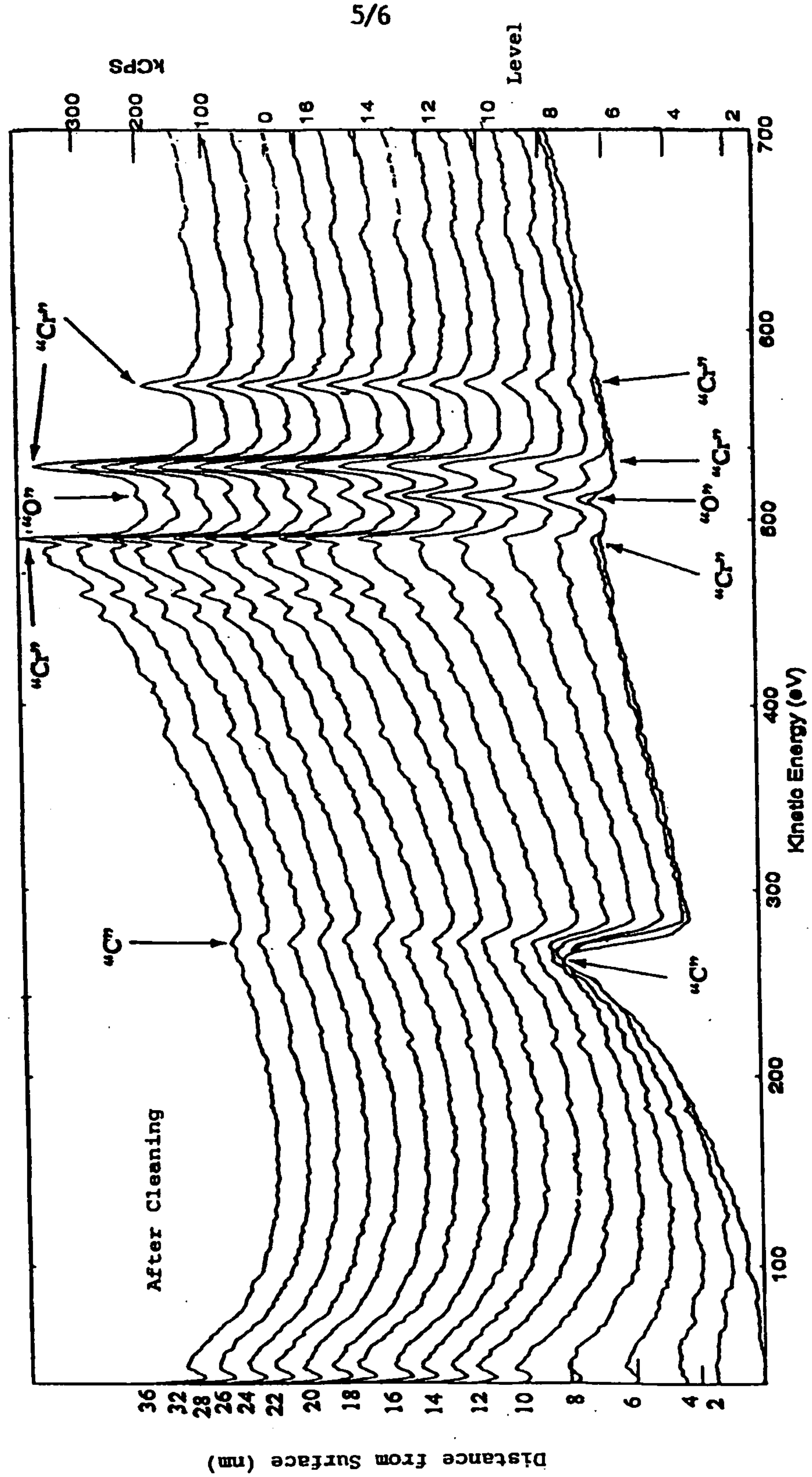
KCPS
Level
After Cleaning
"Cr"
"O"
"C"
Kinetic Energy (eV)
Distance from Surface (nm)

FIG. 5

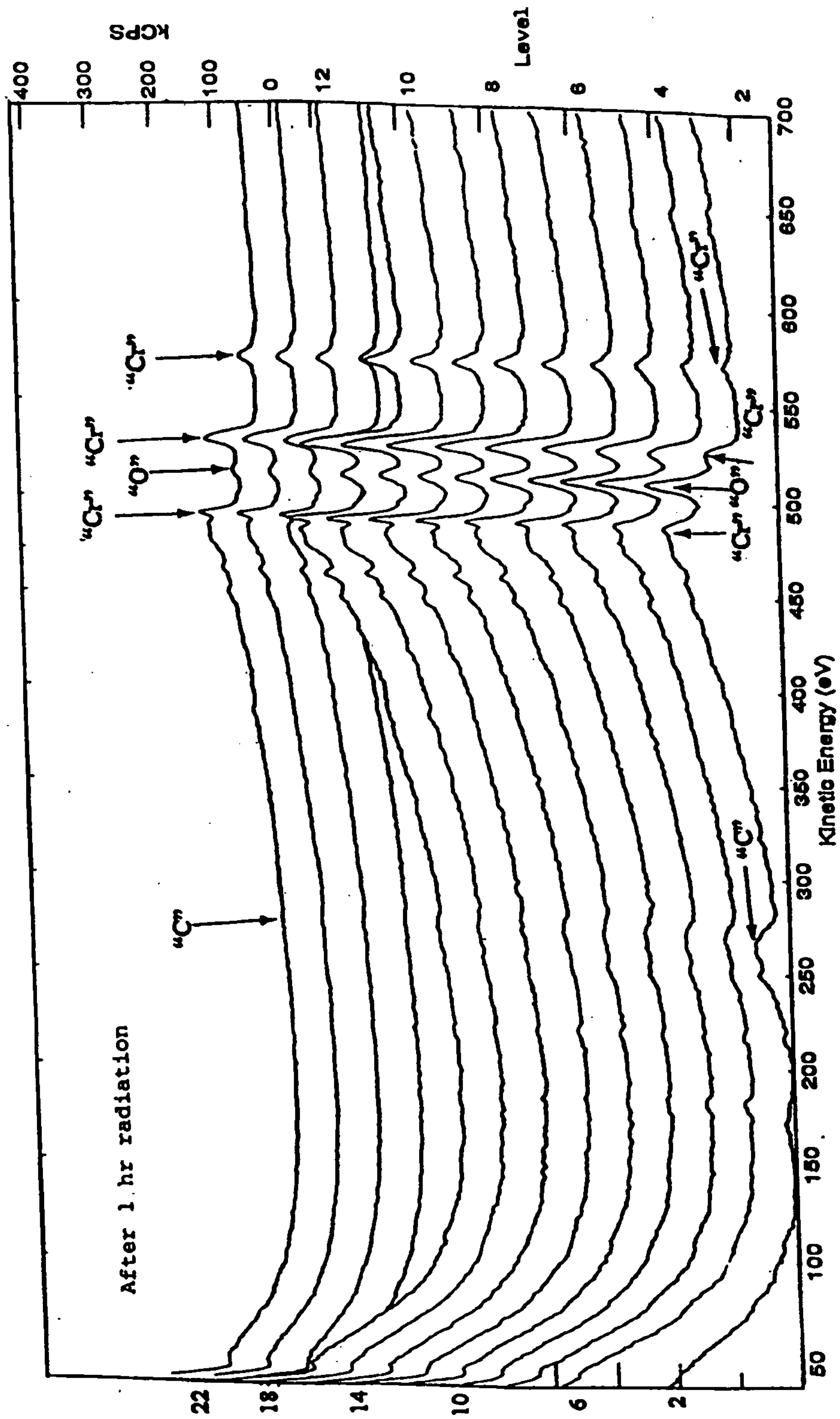
After 1 hr radiation
KCPS
400
300
200
100
0
Level
12
10
8
6
4
2
"Cr"
"O"
"Cr"
"Cr"
"C"
"Cr"
"O"
"Cr"
"Cr"
"C"
22
18
14
10
6
2
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Kinetic Energy (eV)

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/SG 98/00057

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: B08B 7/00, B29C 33/72

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC6 : B08B, B29C 33/06, 33/70, 33/72

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT + keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 94/21418 A (VERNAY LABORATORIES INC.) 29 September 1994 whole document	1-24
X	EP 0792731 A (PIRELLI COORDINAMENTO PNEUMATICI S.p.A) 3 September 1997 whole document	1-24

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" Document defining the general state of the art which is not considered to be of particular relevance

"E" Earlier document but published on or after the international filing date

"L" Document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" Document referring to an oral disclosure, use, exhibition or other means

"P" Document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 September 1998	28 SEP 1998

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929	A. ALI Telephone No.: (02) 6283 2607

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/SG 98/00057

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5023424 A (VAUGHT) 11 June 1991 whole document	1-24
X	EP 0297506 A (IBM DEUTSCHLAND GMBH) 4 July 1989 whole document	1-24
X	DD 242760 A (AKADEMIE DER WISSENSCHAFTEN DER DDR) 11 February 1987 whole document	1-24
X	US 5373140 A (NAGY ET AL) 13 December 1994 whole document	1-24

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No.
PCT/SG 98/00057

This Annex lists the known "A" publication level patent family members relating to th patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	9421418	EP	689492	US	5373140		
EP	972731	IT	96500396	JP	9327832		
US	5023424	JP	4211127				
EP	297506	DE	3721940	JP	1012526	US	4980536
DD	242760	DD	209888				
US	5373140	EP	689492	WO	9421418		

END OF ANNEX